SCIENCE

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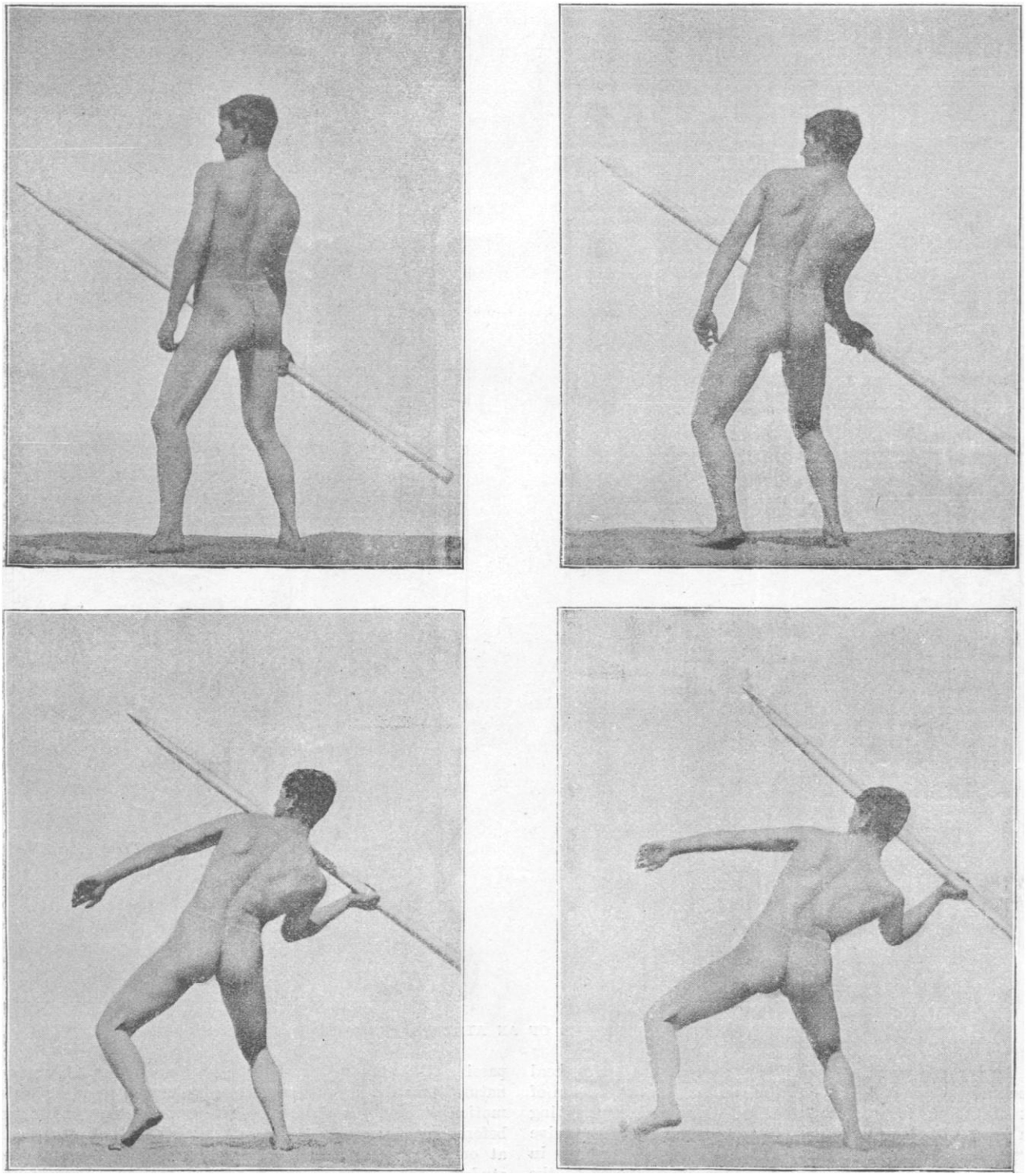
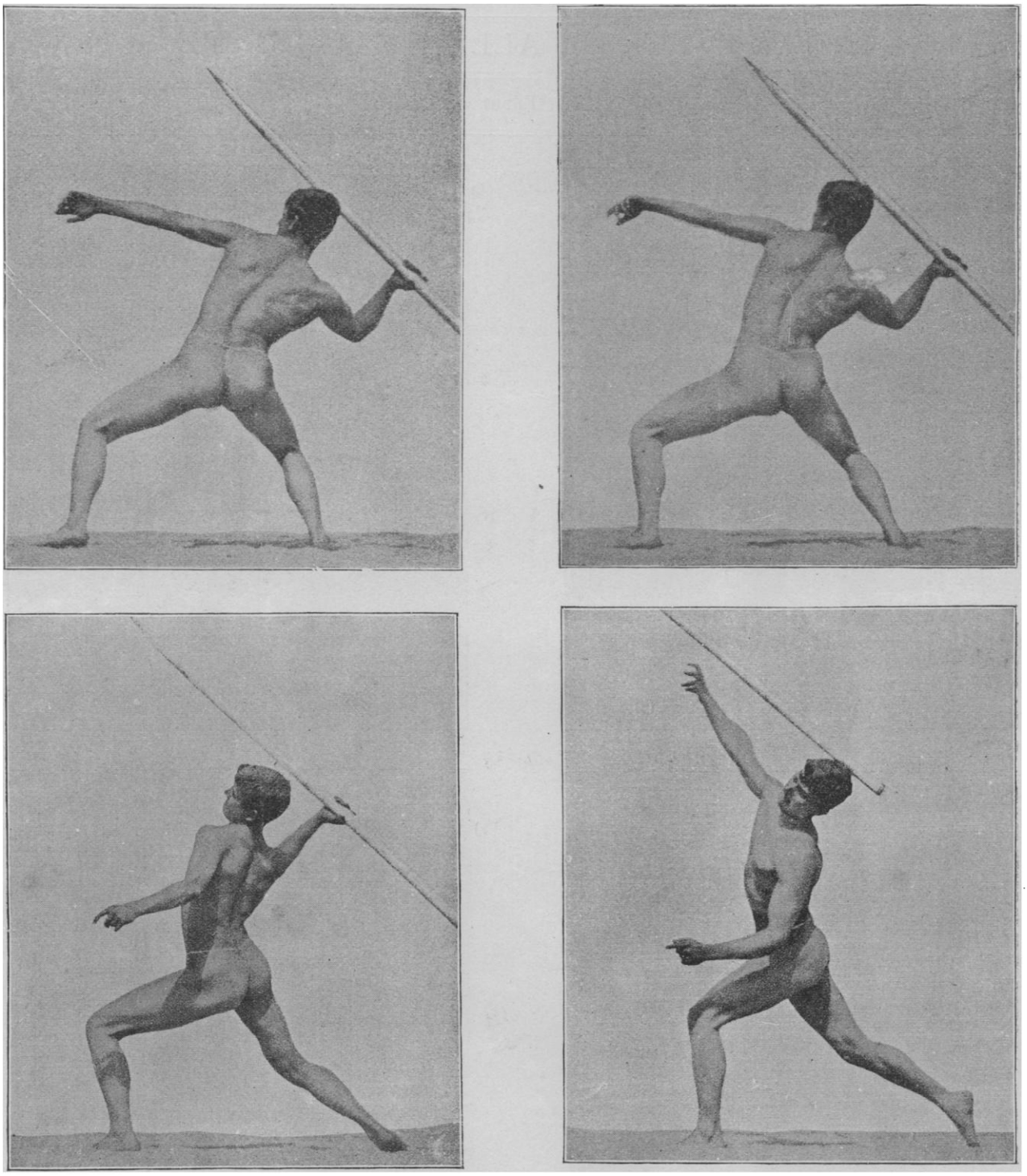


INSTANTANEOUS PHOTOGRAPHS OF AN ATHLETE THROWING A JAVELIN (see next page).

INSTANTANEOUS PHOTOGRAPHY.

IT is a psychological peculiarity of our eye to retain an impression for some time after its source has ceased to exist: thus, if a piece of glowing coal is quickly swung around in a dark room, the eye perceives a circle of light. This is a proof that the eye at a given moment does not see the glowing coal at the place where it happens to be, but that the impression of light of the previous position continues to prevail, thus giving us a composite picture consisting of separate and successive impressions. The same occurs in observing an animal in motion, when the impression we receive is composed of the momentary as well as the immediately preceding positions. It is only by means of photographic apparatus that any single and separate phase of motion can be seized and rendered visible to the eye. Thus it becomes apparent that photography enlarges the power of vision to an extent which is truly wonderful.

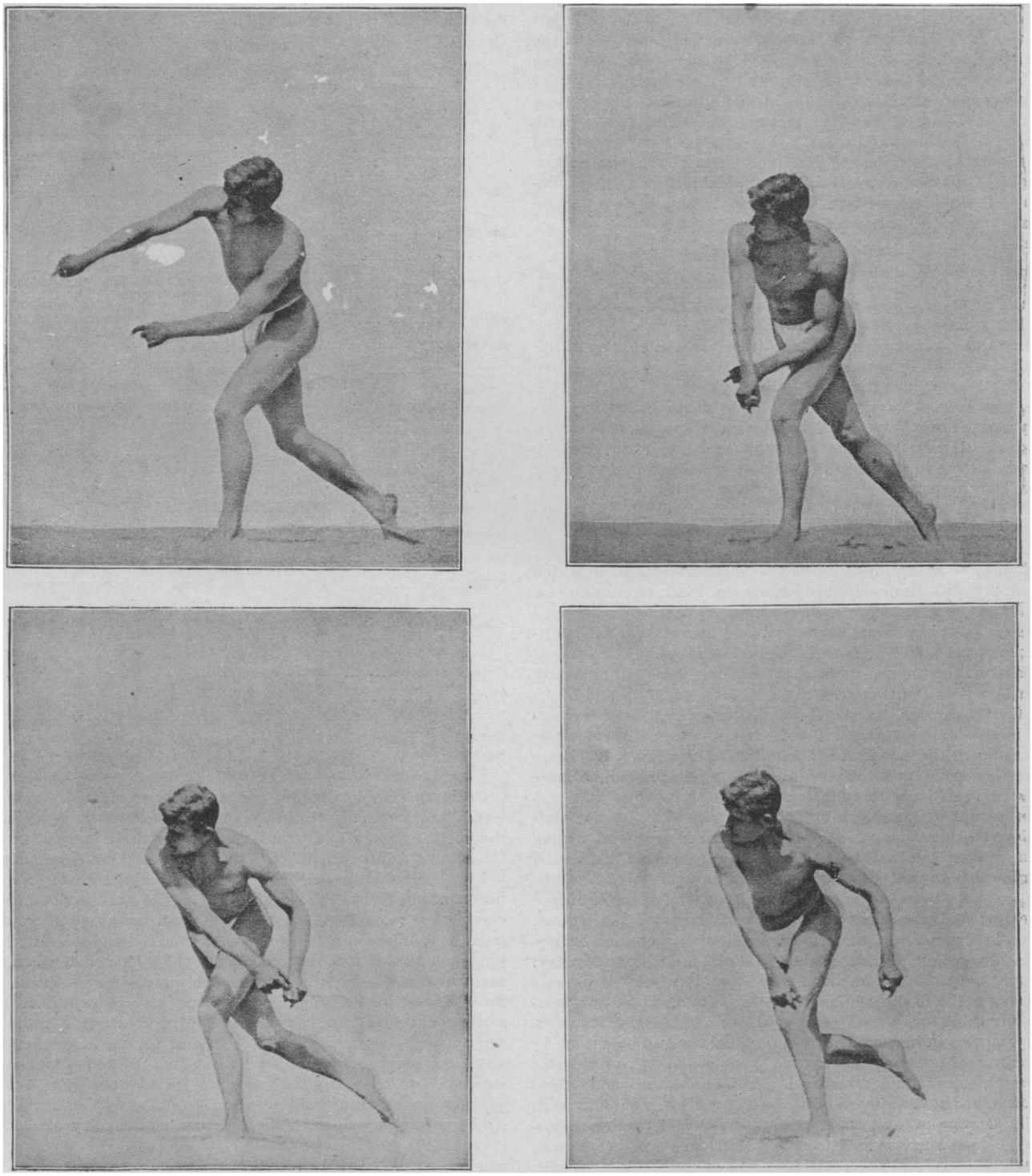
Of course, the sensitiveness of the photographic plate surpassing that of the human eye so many times, it was quite natural that the very first pictures made of men or animals in motion showed many new positions which the eye had never before been able to perceive, and artists as well as scientists at once began to make use of photography for the purpose of studying the phases of rapid animal motion. Prominent in this field of investigation is Mr. Ottomar Anschuetz of Lissa,



INSTANTANEOUS PHOTOGRAPHS OF AN ATHLETE THROWING A JAVELIN.

Prussia, who has taken thousands of pictures of flying birds, running horses, jumping men, etc., all admirable for their perfect "technique," and for the great artistic tact and scientific skill with which the moments of exposure had been chosen. In these pictures the characteristic positions peculiar to different motions are well presented. Many of them at first appear absolutely unnatural, because the eye has never been able to observe them.

These pictures produced rich and important material for the study of motion, but Mr. Anschuetz succeeded in making his experiments more valuable by obtaining whole series of pictures giving the different phases of motion. He made it his object to get of one period of motion, for instance, of the step of a walking man, as many views as possible in equal intervals of time, and he succeeded admirably in his undertaking. He was able to observe in this manner even the fastest motion, for instance, the hurdle-jump of a racing horse, which occupies only seventy-two one-hundredths of a second, and in this short time made twenty-four pictures of the different positions in equal intervals. A dozen pictures showing the different phases of position assumed by an athlete in throwing a javelin, reproduced from instantaneous photographs taken by Mr. Anschuetz, are given on this and the preceding pages.



INSTANTANEOUS PHOTOGRAPHS OF AN ATHLETE THROWING A JAVELIN.

Mr. Anschuetz next constructed an apparatus which he called the electric tachyscope, in which he was financially assisted by the German Government. In this instrument the series o-

pictures is put on a circular glass plate, which is rapidly turned round its axis; and, whenever a picture appears before the eye of the observer, it is lit up by an electric spark. By this means the natural motion of the object is reproduced with a degree of truth and accuracy that is absolutely bewildering. Looking thus at the representation of a man on a galloping horse, every single movement of horse and rider can be followed. Not only do the legs of the horse move according to the gait, but one sees the dust rise, the horse's mane and tail fly, and the nostrils extend. The rider is jerked in his saddle, he urges his horse, pulls the curb-chain, and moves back his leg to apply the spur, etc. Each series in this apparatus represents a bit of life — not a life-like picture, but life itself — with amazing naturalness and truth. One of these tachyscopes, and many notable examples of Mr. Anschuetz's work, have been brought to this country, and are now on exhibition at the show-rooms of the United States Photographic Supply Company on Fourteenth Street, this city.

SOME FOOD SUBSTITUTES AND ADULTERANTS.[1]

MR. PRESIDENT, LADIES AND GENTLEMEN,—In his address before this society last year, our late president, Dr. J. H. Kidder, presented the subject of air as one of the "two necessities of life which," he said, "are absolute," and "which we cannot live without;" namely, "food (including water) and air." It is more especially to a certain class of foods, whose increasing consumption and sale have of late years attracted public notice, that I wish to call your attention this evening; namely, that of cheap and wholesome food substitutes, which are also frequently used as food adulterants.

Our bodies are like a furnace, and require fuel and air to sustain the heat of combustion by the constant renewal of fresh material and the elimination of the waste products. The form, whether solid or liquid, of animal or vegetable origin, in which we supply this fuel, depends largely on local circumstances, climate, education, etc.; and, as long as the food employed goes to furnish the proper amount of fuel material for the maintenance of the body temperature, life is sustained.

The extent of the consumption of any new food will evidently depend on how it fulfils this requirement as a fuel, and by its pleasing appearance, its palatability, its capacity to appease hunger, its wholesomeness, and its relative cheapness, attracts public attention. If the new food is a manufactured product, its cheapness will depend upon the possibility of its production on a large scale from relatively cheap materials.

From want of reliable information in regard to the materials employed in most new food products, there is a general feeling of uncertainty and insecurity on the subject. People, as a rule, imagine that any substance used as an adulterant of, or a substitute for, a food product is to be avoided as itself being injurious to health; and when they hear that a certain food is adulterated, or is a food substitute, there is immediately a prejudice excited against the article, which it takes time and familiarity to allay. A moment's reflection ought to show that it would be directly contrary to the food manufacturer's interest to add to, or substitute any thing for, a food product which would cause injurious symptoms, as in that case his means of gain would be cut off by the refusal of consumers to buy his product. It is true that the unscrupulous manufacturer or dealer does not hesitate to cheat his customer in the interest of his own pecuniary profit and gain, but he does not want to poison him. Where, through carelessness or ignorance, injurious substances, such as the arsenic, copper, aniline, and other metallic and organic poisonous salts sometimes used for artificial colors, are added to foods, their presence is promptly revealed by the dangerous symptoms which they call forth in the consumer. About a year ago the case of the Philadelphia bakers, who added chromate of lead to color some of their cakes, and thus caused the death of several persons, and serious illness in nearly every one who ate any of these products, will be recalled by many present.

[1] Annual address of the retiring president, Mr. Edgar Richards, delivered Jan. 23, 1890, before the Chemical Society of Washington.

The great majority of substances used for food adulterants or substitutes consist of cheap and harmless substances, which are not injurious to health, as the following list of those most commonly met with in the principal food products will show. This list has been compiled from the reports of the State boards of health, the returns of the British Inland Revenue Department, the reports of the British Local Government Board, and those of the Paris Municipal Laboratory.

TABLE I.

Food Products and their Chief Adulterants.

FOOD PRODUCT.	ADULTERANTS.
Milk	Water, removal of cream, addition of oleo-oil or lard to skimmed milk.
Butter	Water, salt, foreign fats, artificial coloring-matter.
Cheese	Lard, oleo-oil, cottonseed-oil.
Olive-oil[1]	Cottonseed and other vegetable oils.
Beer	Artificial glucose, malt and hop substitutes, sodium bicarbonate, salt, antiseptics.
Sirup	Artificial glucose.
Honey	Artificial glucose, cane-sugar.
Confectionery	Artificial glucose, starch, artificial essences, poisonous pigments, terra alba, gypsum.
Wines, liquors	Water, spirits, artificial coloring-matter, fictitious imitations, aromatic ethers, burnt sugar, antiseptics.
Vinegar	Water, other mineral or organic acid.
Flour, bread	Other meals, alum.
Baker's chemicals[1]	Starch, alum.
Spices[1]	Flour, starches of various kinds, turmeric.
Cocoa and chocolate	Sugar, starch, flour.
Coffee[1]	Chiccory, peas, beans, rye, corn, wheat, coloring-matter.
Tea	Exhausted tea-leaves, foreign leaves, tannin, indigo, Prussian blue, turmeric, gypsum, soapstone, sand.
Canned goods[1]	Metallic poisons.
Pickles	Salts of copper.

[1] For list of adulterated brands see Report of the Commissioner of Internal Revenue, 1889, pp. 181–184.

Water.

Ordinary potable water is not generally considered either externally or internally "injurious to health," yet it is probably the most common adulterant used. We find, indeed, in the Canadian "Adulteration Act," that "if water has been added" to milk, "it shall be deemed to have been adulterated in a manner injurious to health" (Section 15). The watering of milk is everywhere recognized as not only a fraud, but also a grave misdemeanor, if not actually a crime. This is the food on which the whole population under one year old is fed; and, where the mother cannot supply the proper nourishment for the child, she must depend for its bringing-up on cow's or other milk. It is self-evident that a pint of watered milk does not contain the same amount of nourishment as the same volume of whole milk, so that a child or invalid might be actually starved to death if compelled to rely on the former for its sole sustenance. The placing of watered and skimmed milk on the market should, in all large cities, call forth the active exertions of their health departments to supervise and as far as possible suppress their sale.

The skill of the milk adulterator has kept pace with the march of improvement, and to-day we find centrifugal machines costing over two hundred dollars placed on the market, designed solely to manufacture, from skimmed milk and oleo-oil and lard, an artificial cream or milk, depending on the amount of animal fat added, which, it is stated, can be used for all purposes in which the genuine article is employed. A description of such machines will be found in *Engineering* (vol. xliv. 1887, p. 478) and in the catalogues of the dealers.

Oleomargarine.

Within the past few years two artificial food products made from what had theretofore been considered waste products of the large slaughter-houses have come prominently before the public, and established a legitimate place for themselves as perfectly wholesome articles of food. Oleomargarine and "refined" or "compound" lard are now found on sale in most cities of this country and Europe. Against the former there has been a large amount of legislation directed with a view of controlling its production and sale, and with the unexpected result of increasing both.

Whatever may have been the production of oleomargarine in this country before the National law went into effect, we have no reliable statistics; but since the 1st of November, 1886, we have the monthly statements of the manufacturers, duly attested under oath, of the quantity of oleomargarine made and removed from the factories, tax paid for domestic consumption or in bond for export, each day of the month. These statements also give the quantity and kind of materials employed in the manufacture, and the names and addresses of the parties to whom the oleomargarine is sold or consigned.

The following table shows the monthly quantity of oleomargarine produced in this country from Nov. 1, 1886, to Nov. 1, 1889:—

TABLE II.

Showing the Quantity of Oleomargarine produced, withdrawn Tax paid, for Export, and Lost or Destroyed in Manufactories, from Nov. 1, 1886, *to Nov.* 1, 1889.

Year.	Quantity Produced. Pounds.	Withdrawn Tax paid. Pounds.	Lost or Destroyed. Pounds.	Withdrawn for Export. Pounds.
On hand Nov. 1, 1886.	181,090			
From Nov. 1, 1886, to Oct. 31, 1887.....	31,114,682	29,692,966	55,260	1,029,880
Highest, March, 1887.	3,568,254	3,512,138	12,472	96,499
Lowest, July, 1887 ...	1,208,638	1,170,136	1,191	33,240
From Nov. 1, 1887, to Oct. 31, 1888.....	35,530,146	33,655,423	6,442	1,937,907
Highest, March, 1888.	3,940,727	3,824,672	2,998	155,761
Lowest, July, 1888....	2,084,317	1,925,762	185	155,200
From Nov. 1, 1888, to Oct. 31, 1889.....	35,132,060	32,902,802	6,741	1,694,851
Highest, Dec., 1888...	4,181,317	4,025,336	10	109,385
Lowest, June, 1889....	1,575,362	1,514,658	—	58,579
On hand Oct. 31, 1889.	429,219			
Total for 3 years.....	101,786,888	96,251,191	68,443	4,662,638

During this period the number of factories has decreased from 37 to 21, notwithstanding which fact the production and sale have increased steadily. It is produced by expensive machinery in the large factories in such quantities that it can be sold nearly the whole year round at a less price than butter, although the high rate of tax paid by both the manufacturers and dealers, which is, of course, ultimately paid by the consumer, necessarily increases the market price. In the spring and early summer months the price of dairy butter is generally cheaper than oleomargarine, and consequently less of the latter is made and sold during that time. In July the production of oleomargarine reaches its lowest limits for the year, and obtains its highest in March.

The system followed by the Internal Revenue Bureau is such that each manufacturer's package can be traced from the time it leaves the factory till it reaches the hands of the retailer or consumer, or leaves the country.

The high rate of tax demanded from the manufacturers and dealers was undoubtedly intended to be nearly or quite prohibitory: when compared to those paid by other special tax-payers, rectifiers, brewers, etc., as shown in the following table, the amounts are from three to ten times as high:—

TABLE III.

Rate of Special Taxes per Annum.

	Oleomargarine.	Liquors.		Tobacco Manufactured.
		Distilled.	Malt.	
Manufacturer..... ..	$600 00	$200 00*	$100 00†	$6 00
Wholesale dealer.....	480 00	100 00	50 00	30 00‡
Retail dealer.....	48 00	25 00	20 00	2 40

* Rectifier of 500 barrels, or more, per annum.
† Annual manufacture, 500 barrels or more.
‡ Pedler of tobacco, first-class.

It is undoubtedly a fact that if the retailer's tax was as low as that for tobacco, the manufacturers of oleomargarine would pay the same to have at least one dealer to handle their goods in every village and town in this country. As it is, in the Chicago district, where there are seven factories, there were 974 retail dealers doing business in April, 1889, compared with 726 the April previous; in the Boston district, with its one factory, there were 460 retailers in April last year, and 405 at the corresponding time in 1888; in the Connecticut district, with four factories, there were 424 in 1889, and 384 the year previous; and in Michigan, with no factory, there were 290 and 267 respectively for the same periods. These four collection districts contain over one-half of the total number of retail dealers doing business at the close of the last special tax year (April 30, 1889). This would seem to indicate that where the public has been brought in unprejudiced contact with oleomargarine, as sold on its own merits, they have found it palatable and suitable to their wants.

I have been in retail stores in the lumber and mining regions of the upper peninsula of Michigan, in Boston, Chicago, and elsewhere, where as much as one-half to one ton of oleomargarine is sold per week, in quantities of less than ten pounds to any one purchaser at one time, put up in packages duly branded with the word "Oleomargarine," as required by the law and regulations. It may interest you to know that there was consigned to retail dealers, and presumably sold in Washington, between Jan. 1, 1889, and Dec. 1, 1889, 130,584 pounds of oleomargarine, as shown in the following table:—

TABLE IV.

Showing Monthly Shipments of Oleomargarine from Five Manufacturers Direct to Retail Dealers in Washington, D.C., from Jan. 1, 1889, *to Dec.* 1, 1889.

Month.	*Lbs. Oleomargarine.*
January.....	10,270
February.....	28,223
March.....	6,227
April.....	8,108
May.....	12,372
June.....	6,808
July.....	6,826
August.....	8,466
September.....	13,872
October.....	12,844
November.....	16,568
Total.....	130,584

The ingredients which enter into the manufacture of oleomargarine are (1) neutral or leaf lard, used in the proportion of from 25 to 60 per cent, made from the leaf fat of freshly slaughtered hogs; (2) oleo-oil, used in the proportion of from 20 to 50 per cent, made from the caul and suet fats of freshly slaughtered beeves; (3) some liquid vegetable oil, as cottonseed, sesame, peanut, used in the proportion of from 5 to 25 per cent, made by crushing the seeds and extracting the oil by pressure or solvents; (4) milk or cream, used in the proportion of from 10 to 20 per cent; (5) butter, used in the proportion of from 2 to 10 per cent, generally bought from the best creameries for its fine

flavor; (6) salt; and (7) annatto or other coloring-matter. Some factories employ no vegetable oils in their oleomargarine, preferring to use a larger proportion of "neutral" lard with a small amount of butter to obtain the desired butter consistency. In the higher grade of "creamery butterine" the proportions of oleo-oil are reduced, the vegetable oils are discarded, and butter is used to make up the charge for the churn.

The method of manufacture closely resembles that used in ordinary butter-making, except that the churn is steam-jacketed and the animal fats used are previously melted before being placed in it. From a personal inspection of some of the largest factories, I am convinced that the greatest cleanliness is observed throughout all the operations; that nothing but the freshest animal fats are used; that machinery is employed as much as possible, and large quantities worked at a time, to reduce the expense. The factories are as well arranged as the best creameries; and it is to the manufacturer's interest to produce a palatable and wholesome product, which is, however, not intended to compete with "gilt-edge" butter.

Oleo-Oil.

Owing to the construction by the attorney-general of Section 2 of the oleomargarine law, the internal revenue officers exercise no control over the production and sale of oleo-oil, although the commissioner has recommended that Congress amend the law in that regard. From inquiries that were made over a year ago by the collectors of internal revenue, there was found to have been produced during the year ended June 30, 1888, 69,623,795 pounds of oleo-oil in nine States. There was used in the manufacture of oleomargarine, as stated in the manufacturers' returns, 12,265,800 pounds during that period, and 30,146,595 pounds were exported, leaving 27,211,400 pounds used otherwise. As oleo-oil is sold at a much higher rate than tallow, it is presumable that this large quantity is used in some other food products, as emulsified cream and cheeses.

There is a special provision in the law in regard to the use of any unwholesome material or product in the manufacture of oleomargarine, but no sample has ever been submitted to the commissioner of internal revenue under it. From the testimony and investigations of the most prominent chemists, both here and in Europe, there is a consensus of opinion that oleomargarine, when made from fresh fats and in a cleanly manner, is a perfectly wholesome article of food.

Compound Lard.

In the manufacture of oleo-oil there is left behind on the filter-presses a hard white or slightly yellow fat, the beef or oleo-stearine. This for many years was sold to the candle and soap makers, but is now used in the extensive manufacture of "refined" or "compound" lard by being melted and mixed with some cottonseed-oil and a little leaf-lard until the mixture has attained the desired consistency.[1]

From the testimony given before the Congressional Lard Committee, "prime steam lard" is about as disgusting a mixture as can be imagined. The entrails and other viscera, head, feet, in fact every part of the animal which contains the faintest traces of fat, are dumped into the rendering-tanks, and live steam turned on until all the fat is thoroughly melted out. The liquid is then allowed to cool, the water containing a highly savored mass of impurities is run off, and the remaining fat is tierced or canned. If it smells too "loud," it is washed with hot water, allowed to cool, and then repacked.

The oleo-stearine and cottonseed-oil mixture is prepared from clean and wholesome materials, and does not suggest any such filthy practices as "prime steam lard." The manufacturers are generally abandoning the designation of "refined," and are now calling such mixtures "compound lards."

Cottonseed-oil.

The enormous and constantly increasing production of cottonseed-oil in this country is noteworthy as showing to what an extent it has come to be employed as an article of food, both here and abroad. The principal domestic consumption of the oil is in the manufacture of "compound lard." It is also used as a substitute for, and an adulterant of, olive-oil for cooking and table use, and in medicinal preparations. It is employed instead of the more expensive animal and vegetable oils in the mining regions for the miners' lamps. There are a hundred and twenty-five mills in operation, with a capital invested, in the South, estimated at $25,000,000. Twelve thousand hands, receiving $24,000, are employed per day. The amount of seed crushed last season was 875,000 tons,[1] yielding, on an average, 37½ gallons of crude oil per ton.

Some Queer Prejudices.

A large proportion of the articles suitable for food, and produced in all countries, is wasted annually because of people's prejudice against them. The old saws, "What is one man's meat is another man's poison," and "There is no accounting for taste," are trite, but warranted by the facts.

We do not object to eating a live oyster, but prefer all our other meats dead, and undergoing putrefaction to a slight extent, in order to get rid of the "toughness," as it is generally called, produced by the *rigor mortis*. Some people like to let the putrefaction proceed further until the meat is "gamy." The Texan cowboy eats goat's meat in preference to that of the cattle and sheep he is herding. Young puppies, rats, and bird's nests are considered delicacies by the Chinese. Frog's legs and snails are among the highest priced dishes served at Delmonico's. Except the bones and hide, every part of an animal slaughtered for food is eaten by most civilized nations,— the brain; tongue; blood in the shape of black pudding and sausages; the liver; heart; lungs; stomach as tripe; the pancreas, thyroid and sublingual glands, which are called sweetbreads, and considered a great delicacy; the feet in the way of jellies, and pickled; the intestines as sausage covering, etc. In the markets of Paris there is a steady demand for horse-flesh as food. The Arabs and other nomadic tribes prefer mare's or camel's to cow's milk. Many people would as soon eat a snake as an eel, yet the latter commands a higher price than most fish in many parts of the world. Lobsters, which are the scavengers of the sea, are eaten by people who would not touch pork. The Eskimo, who eats blubber and other solid fats, and the native of the tropics, who "butters" his bread with a liquid vegetable oil, have the same object in view; viz., to supply a concentrated form of fuel. The squirrel is considered a great delicacy in many parts of this country, but is not eaten in England. The vain efforts of Professor Riley some years ago to induce the starving people of Kansas to eat the food they had at their doors,— grasshoppers, sorghum, and millet seeds, and squirrels,— himself setting them the example, will be recalled by many present.

Cooking.

From experiments made by Jensen in the laboratory of the University of Tübingen, it appears that raw meat is much sooner digested than cooked meat. Cooking, as far as animal food is concerned, has the effect of making it more pleasing to the taste, but is unnecessary; whereas with certain vegetables, especially those composed principally of starch, as grain and potatoes, it is required to fit them for use. The proper preparation of food is one that has not received the attention it demands. A badly cooked meal is more apt to disorganize the system than to prove nutritious and beneficial. The general teaching of cookery in our schools, both public and private, to girls would undoubtedly result in much improvement in this regard.

Glucose.

In April, 1882, the commissioner of internal revenue addressed a letter to the president of the National Academy of Sciences, requesting "the appointment of a committee of the academy to examine as to the composition, nature, and properties of the article commonly known as 'glucose' or 'grape-sugar.'" In the report on this subject, made in January, 1884, the committee, consisting of Professors Barker, Brewer, Gibbs, Chandler, and

[1] My thanks are due to Messrs. Fairbanks & Co. of Chicago for a set of samples illustrating the manufacture of compound lard.

[1] This information was kindly furnished me by Mr. A. D. Fulton, editor of the Oil, Paint, and Drug Reporter, in a letter dated Dec. 28, 1889.

Remsen, from the results they had obtained, summed up briefly as follows:—

"1st, Starch-sugar as found in commerce is a mixture, in varying proportions, of two sugars, called dextrose and maltose, and of dextrine, or starch-gum. Dextrose was discovered in grapes by Lowitz in 1792, and was first prepared from starch by Kirchhoff in 1811. In 1819, Braconnot prepared it from woody fibre. Maltose was first recognized as a distinct sugar by Dubrunfaut, in 1847, in the product of the action of malt on starch. No dextrose is thus produced, according to O'Sullivan.

"2d, The process of making starch-sugar consists, first, in separating the starch from the corn by soaking, grinding, straining, and settling; and, second, in converting the starch into sugar by the action of dilute sulphuric acid, this acid being subsequently removed by the action of chalk. To make the solid, 'grape-sugar,' the conversion is carried further than to make the liquid, 'glucose.' After clarifying, the liquid is concentrated in vacuum-pans, and is decolorized with bone-black.

"3d, The starch-sugar industry in the United States gives employment to twenty-nine factories, having an estimated capital of five millions of dollars, consuming about forty thousand bushels of corn per day, and producing grape-sugar and glucose of the annual value of nearly ten millions of dollars. In Germany, in 1881–82, there were thirty-nine factories of this sort, consuming over seventy thousand tons of starch, and producing about forty thousand tons of starch-sugar."

Since this report of the National Academy was printed, the number of starch-sugar factories in the United States has decreased to twelve, with a capital invested estimated at from twelve to fifteen million dollars, consuming about fifty thousand bushels of corn per day, and having an annual production of 450,000,000 pounds, valued at $10,500,000.[1]

"4th, Starch-sugar is chiefly used in making table-sirup, in brewing beer as a substitute for malt, and in adulterating cane-sugar. It is also used to replace cane-sugar in confectionery, in canning fruits, in making fruit-jellies, and in cooking. Artificial honey is made with it; and so, also, is vinegar.

"5th, Starch-sugar represents one distinct class of sugars, as cane-sugar does the other; the former being obtained naturally from the grape, as the latter is from the cane and the beet. Starch-sugar, which is a term chemically synonymous with dextrose and glucose, when pure, has about two-thirds the sweetening power of cane-sugar. By the action of the dilute acids, both cane-sugar and starch yield dextrose. In the case of starch, however, dextrose constitutes the sole final product.

"6th, The commercial samples of starch-sugar obtained by the committee showed a fairly uniform composition on analysis. The liquid form, or 'glucose,' contains from 34.3 to 42.8 per cent of dextrose, from 0 to 19.3 per cent of maltose, from 29.8 to 45.3 per cent of dextrine, and from 14.2 to 22.6 per cent of water. The solid form, 'grape-sugar,' gave from 72 to 73.4 per cent of dextrose, from 0 to 3.6 per cent of maltose, from 4.2 to 9.1 per cent of dextrine, and from 14 to 17.6 per cent of water. Three specimens of especially prepared 'grape-sugar' contained 87.1, 93.2, and 99.4 per cent of dextrose respectively. The last of these was crystalline anhydrous dextrose.

"7th, Of mineral or inorganic constituents, the samples of starch-sugar examined contained only minute quantities. The total ash formed in the 'glucose' was only from 0.325 to 1.060 per cent, and in the 'grape-sugars' only from 0 335 to 0.750 per cent. No impurities, either organic or inorganic in character, other than those mentioned, were detected in any of the samples examined.

"8th, The elaborate experiments upon the fermentation of starch-sugar would seem to be final on the question of the healthfulness, not only of glucose itself, but also of the substances produced by the action of a ferment upon it. Large quantities of a concentrated extract from the fermentation, representing from one-third to one-half a pound of starch-sugar, were taken internally by the experimenter, and this repeatedly, without the slightest observable effect. This result, rigidly applied, holds of course only for those sugars which, like this, are made from the starch of Indian-corn or maize."

From the foregoing facts the committee reached the following conclusions: "First, that the manufacture of sugar from starch is a long-established industry, scientifically valuable and commercially important; second, that the processes which it employs at the present time are unobjectionable in their character, and leave the product uncontaminated; third, that the starch-sugar thus made and sent into commerce is of exceptional purity and uniformity of composition, and contains no injurious substances; and, fourth, that though having at best only about two-thirds the sweetening power of cane-sugar, yet starch-sugar is in no way inferior to cane-sugar in healthfulness, there being no evidence before the committee that maize-starch sugar, either in its normal condition or fermented, has any deleterious effect upon the system, even when taken in large quantities."[1]

Some Other Adulterants.

The use of flours and starches of various kinds—wheat, corn, rye, peas, beans, etc. — as food adulterants cannot be considered injurious to health. However much the public may be cheated in the purchase of such adulterated articles of food, as ground spices, coffee, etc., they are not poisoned by their consumption It is a question how much a purchaser is himself to blame, in his endeavor to secure a "bargain," when he demands so great a quantity of any given material at less than it can be purchased at wholesale in the market, that he compels the unscrupulous manufacturer to make a compound which has never more and generally less than the proportion of the genuine material represented by the price asked.

Many articles of food spoil in transportation; and, under the plea of preventing further fermentation, resort is had to antiseptics, such as salicylic acid, sulphite of soda, borax, etc. These deserve mention as being additions to foods of a class of substances used to cloak carelessness in manufacture and otherwise, and producing in many cases deleterious effects on the human economy. In France and Germany the use of such antiseptics as salicylic acid in food products is prohibited, although in the latter country such addition is tolerated when the food product is exported to countries where such use is not prohibited.

Legislation on Food Adulteration.

The adulteration of food, generally being aimed at the pocket and not at the health of the consumer, ought to be easily remedied, one would suppose, by legislation. On, however, turning to our different State laws on the subject, I am sorry to say that most of them are drawn up in a follow-the-leader style, under the popular but erroneous impression that any substance used as an adulterant of or a substitute for a food product is necessarily injurious to health, with the consequence that these laws are, with very few exceptions, merely dead letters.[2] New York and Massachusetts have laws nearly identical in wording, whose enforement is intrusted to their respective boards of health. In the former State the law has proved a failure, because in an action brought to obtain "an injunction against the sale of certain Ping Suey teas it was held by the court, in refusing to grant the same, that, although the teas in question had been clearly shown to be adulterated with gypsum, Prussian blue, sand, etc., it was likewise necessary to prove that the effect of these admixtures was such as to constitute a serious danger to public health"[3] In Massachusetts, however, the law has been enforced with vigor by the State Board of Health, and the yearly reports show a diminution in the percentage of adulteration of the samples submitted to analysis.

In this country the British Sale of Food and Drugs Act, 1875, with all its imperfections, has served as a model for our legislation; and until we have a general law on the subject, drawn up

[1] This information was kindly furnished me by the American Glucose Company of Buffalo, N.Y., in a recent letter, December, 1889, who also sent samples of liquid and solid glucose.

[1] Report on Glucose, prepared by the National Academy of Sciences, in response to a request made by the commissioner of internal revenue, Washington, 1884.

[2] For list of State laws on food adulteration see Report of the Commissioner of Internal Revenue, 1888, p. ccix.

[3] Battershall, Food Adulteration and its Detection, p. 8 (New York, 1887).

with clear definitions of adulteration, and adequate means for the enforcement, by the co-operation of State and National authorities, of its provisions in regard to this class of fraud, the food sophisticator will pursue the even tenor of his way undisturbed. The European Continental legislation on this subject is much superior to the English act.[1] Under Continental statutes, every dealer is held responsible for the quality of his merchandise, whether of foreign or domestic origin, and every food material must be sold under its true name; artificial products imitating a natural product must be properly labelled in a conspicuous and legible manner; all unwholesome foods are confiscated and destroyed without compensation to the owner; and adulterations generally are considered acts of fraud. Suitable police supervision and control are provided for the enforcement of these statutes; and, although these laws are somewhat of a paternal nature, they are much more effective than any we have.

The average American repudiates the idea of a paternal government supervision over his affairs, or any thing tainted with the idea. He realizes that he is a full-grown man and a sovereign, and that therefore he is perfectly competent to take care of himself; and no cheat or swindler can ever get the better of him. He may be willing to support, even to clamor for, a legislative measure to regulate the production or sale of a food product, provided it advances his particular business interests. He would, however, regard with apathy any general law that would guarantee to the public the liberty of purchasing pure food, with a reasonable certainty that they were not imposed upon in their purchases, if it was incumbent on him to take the necessary steps to execute its provisions by bringing samples for analysis, etc.

It may be, however, that some day he will reach the conclusion that his individual smartness, great as it may be, is not sufficient to wage successful warfare against the food sophisticator's combinations, which have made this country for years the choice dumping-ground of the frauds of Europe, Asia, and Africa. When this happens, we may hope that the proper laws will be passed to suppress the fraud, and that we, the chemists of the country, will have opened to us a new field of usefulness,—a field in which we ought to put forth our best efforts, with the constant aim to maintain the purity and wholesomeness of the food for suffering humanity.

[1] For copies of European laws on food adulteration see Reports of the Commissioner of Internal Revenue for 1888 and 1889; and for a summary of their leading features see Science, 1 9, xiv. p. 308.

THE ORIGIN OF HUMAN FACULTY.

IN a paper read before the Neurological Society, Dr. Romanes has presented in very convenient shape an outline of his recent work, "Mental Evolution in Man," which, being at once authoritative and brief, may be appropriately noticed in these columns. Taking for granted the truth of his first proposition, that no exception must be made in the case of the human mind to the law of continuous evolution,—a proposition fully discussed in the original work,—Dr. Romanes concentrates his energies upon tracing the probable causes and history of this transition from the intelligence of brute to that of man.

For this purpose it is found necessary to agree upon a working classification of mental products or ideas. The division adopted is that of simple ideas, which are simply the traces left in the mind by a sense-impression,—the seeing with the mind's eye, as it were; of compound, or, better, generic ideas, which are obtained by a fusion of several impressions, and so involve some amount of comparison; and, finally, of general ideas, which are named abstractions,—a symbolic mode of referring to a group of ideas. These may be more briefly referred to as percepts, recepts, and concepts. The first two are common to animals and men. A dog has a generic idea of man, and a simple idea of some particular man; but he cannot make the third step, and call the one by the word "man" and the other by the word "John." This is the distinction most usually insisted upon as dividing men from the most intelligent of animals, and not only involves a substitution of a symbol for an idea, but, to get this idea, requires the mind to look in upon itself and observe its own actions,—introspection or self-consciousness. While these concepts may at first be very simple, they may be subjected to mutual comparison, and the relations thus deduced again give rise to concepts, and thus a kind of algebra of recepts and their corresponding concepts be formed,—an algebra of the imagination, in which all the higher intellectual work is accomplished. Now, the difference between a mind capable of however limited a degree of conceptual ideation and one having only receptual ideation is usually agreed to be the possession of language by the first, and its absence in the other. We must therefore consider the mental powers involved in language. Language, considered broadly, is the faculty of making signs: this intelligent animals do. The dog barks to have the door opened, a parrot will give rise to sounds to express its wants, and so on. But there is a broad difference between this which is receptual sign-making, and the peculiarly human conceptual sign-making. The man can think about the name, which is to the animal merely an association of sound with thing. "The difference between naming a thing receptually by mere association, and naming a thing conceptually by intentional thought, is all the difference between knowing that thing and knowing that we know it." It is, then, the genesis of the self-conscious faculty that forms the special object of study,—the faculty that enables us to think of words as words, and of ideas as ideas. But we must remember that even in the human infant there is a stage of sign-making anterior to self-consciousness. There is first the indicative stage, in which the child, like the dog or parrot, makes intentionally significant signs or tones; there is then the denotative stage, in which the child uses names receptually by mere association, just as the talking birds do; upon this follows the connotative stage, in which a child will apply a name not alone to the object with which it was first learned, but also to objects with varying degrees of similarity to it,—will extend the meaning of "bow-wow" from the house terrier to other dogs, to pictures of dogs, to a person imitating the dog, etc. (parrots have been observed to possess the rudiments of this connotative stage); lastly there is the denominative stage, where the name is consciously bestowed as such (this occurs in the child between the second and third years, when the child arranges its names in statements). It is important to note that the first three stages occur in animals, but that they occur in a very much more perfect development in the child, before it reaches the distinctively human form of speech. The receptual intelligence of the child is greatly in advance of that of any animal; although this supremacy must not blind us to the fact that it is a difference of degree only, and not of kind. This preconceptual intelligence of a child is superior to that of a dog in the same sense as the dog is more intelligent than a bird. An intelligent chimpanzee, Dr. Romanes believes, would "follow a child through what would probably seem a surprising distance in the use of denotative names and receptually connotative words," if it had the power of articulation; and it would, too, under this condition, have been able to "answer us in the same way that a child answers us when first emerging from infancy." From here on, the child rapidly advances beyond the capacity of any animal, though it has still a long development to pass through before it reaches the truly human or self-conscious stage. A very large share of mental activity at this period is formed by the making of propositions which, to distinguish from the later propositions, may be called preconceptual propositions. If a child sees its sister crying, and its words for the person and the act are "Dit ki," this is a statement, but one made for the child by the "logic of events." It is not conceptual or introspective, but is of the "psychological kind that we might have expected a monkey to make, if a monkey had been able to pronounce denotative names as well as it can understand them." Up to this point we have been considering differences of degree only: the issue is thus narrowed down to the transition from the preconceptual to the conceptual stage.

Here we must note that even in the lower animals we find some of the conditions to the subsequent appearance of self-consciousness in the more gifted intelligence of man. The animal mind has a store of images to a certain extent independent of sensuous impressions. Animals dream, pine for absent friends, seem subject to hallucinations, etc. The brute, too, is able to "establish true analogies between its own subjective states and the corresponding states of other intelligences." The individual so far realizes its own individuality as to recognize that it is one of a kind, and thus has a rudimentary or nascent self-consciousness. This in the child is supplanted by a pre-conceptual self-consciousness, which is exhibited by all children after they have begun to talk, but before they begin to speak of themselves in the first person, or show that they realize their own personality. It is the recognition of self as an active and feeling agent, but involves no introspection. At this stage, then, the child has the characteristics just described as common to itself and the animal, but, in addition, has far better apparatus for sign-making, a better knowledge of others' states of mind, a better faculty of denotative utterance, and so on. Here the interval between denotation and denomination becomes so narrow that the step is easy. "The mere fact of attaching verbal signs to mental states has the effect of focusing attention upon those states; and, when attention is thus focused habitually, there is supplied the only further condition which is required to enable a mind, through its memory of previous states, to compare its past with its present, and so to reach that apprehension of continuity among its own states wherein the full introspective consciousness of self consists." Now, this step, though an important one, is not so important as to warrant our supposing it a step different in kind from the other steps of mental evolution, especially if we remember, that, even when self-consciousness appears, the human mind is in an infantile condition, and if we take into account the enormous difference in intelligence of a child and of a youth, where a difference in kind is out of the question.

We must add to this picture of individual development the parallel evidence of racial development. This evidence shows that the several distinctively human steps of thought were in ages past difficult or impossible. Of especial importance is the evidence of language. "The gradual evolution of articulate language has preserved for us a kind of paleontological record of the gradual evolution of conceptual thought, with the result of showing that in the life-history of the human species, as in the life-history of the individual child, this conceptual thought derived its origin from these preconceptual levels of ideation which have already been occupying our attention." In brief, then, Dr. Romanes concludes, that, on the basis of an exact psychological analysis, the differences between the intelligence of man and brute, though presenting marked contrasts, yet seem to be connected by intermediate stages, which should be regarded as differing in degree rather than in kind, and that this view is strengthened by considering the slow and painful steps of human intelligence, from its beginnings in savagery to its present lofty attainments, at first view so entirely separating, mentally, man from the rest of creation.

HEALTH MATTERS.

The Nutritive Value of Boiled Milk.

THAT the sterilization of milk, however important, is not without its disadvantages, has been shown by Randnitz and others. To determine the comparative assimilability of proteids and fats from boiled and non-boiled milk, Dr. Evsevy V. Vasilieff of St. Petersburg undertook a course of most careful experiments on six healthy young men, aged from eighteen to twenty-three years. Each experiment lasted six days, during three of which the men received raw milk, and during the other three boiled milk, the daily amount of the article in either case varying between 1,850 and 4,200 cubic centimetres. The following, according to the *Provincial Medical Journal*, are the conclusions deduced by the author from his very instructive researches:—

1. The assimilation of nitrogenous ingredients from boiled milk is invariably less than that from the raw article. In the case of raw milk the average percentage of non-assimilated nitrogen amounts only to 7.05, the maximum to 7.62, and the minimum to 6.42; while in the case of boiled milk the respective figures are 8.18, 8.79, 7.76.

2. The same holds true with regard to the assimilation of fats. When fat is ingested in a raw state, the average percentage of non-assimilated fatty acids is 3.89, the maximum 4.85, and the minimum 2.88. In the case of boiled milk, however, the figures rise to 6.01, 6.99, and 4.53 respectively.

3. Boiling seems to affect especially the assimilation of the fats of milk, since the percentage of fatty acids in relation to the total quantity of dried fæces in those fed on boiled milk is considerably larger than in those fed on non-boiled milk. In the former case, fatty acids constitute 19.03 per cent of the total amount of dry fæces; but in the latter, not more than 16.81. In other words, when a person ingests his milk boiled, every 100 grams of his dry fæces contain a surplus of fats amounting to 2.22 grams.

4. Therefore, as regards its nutritiousness, boiled milk represents a decidedly inferior dietetic article, compared with raw milk.

5. As far as proteids are concerned, the difference in their assimilation may find some explanation in Dr. I. Schmidt's researches, according to which, under the influence of boiling, cow's milk undergoes important chemical changes, nearly all the albumen and a part of the caseine being transformed into hemi-albumose. Schmidt's analysis proves that raw cow's milk contains 8.55 per cent of caseine, 8.4 of albumen, and 6.1 of hemi-albumose. Under the influence of ten minutes' boiling, the proportion of caseine sinks to 7.59 per cent, that of albumen to 0.7, while that of hemi-albumose rises to 23.4.

TRICHINÆ IN SWINE. — Professor E. L. Mark has recently published the results of the examination of 3,064 hogs raised in the vicinity of Boston, Mass. (*Report of Massachusetts State Board of Health*). The examination extended over the five years 1883 to 1888. The results show that 14.07 per cent of the males and 10.61 of the females were infected with trichinæ. Similar examinations of Western hogs have shown only from two to three per cent to be infected. Professor Mark reaches the conclusion that this difference is probably due to the character of the food given to those raised in the vicinity of Boston, and presumably in the vicinity of other large cities. Of the fifty-six raisers of the hogs examined by him, fifty-one fed city offal. The source of the infection he believes to be in the uncooked meat found in kitchen garbage. It would be interesting to know the condition, in this respect, of the large number of hogs fed upon this food in and about the other large cities, says the *Brooklyn Medical Journal*.

THE PSYCHOLOGY OF EPIDEMICS. — Every epidemic carries in its train curious exaggerations of many well-recognized characteristics, and these frequently call for appreciation and for treatment almost as much as the disease in which they originate. Perhaps one of the most striking of these mental perversities is to be found in the idea that the epidemic is to be treated by "common sense" or by nostra which have been largely advertised, or by specifics which are known to the laity mainly through their frequent mention in the daily press. Those suffering under this delusion feel that it is wholly unnecessary to seek skilled assistance, and they boldly dose themselves with remedies of whose power and properties they are absolutely ignorant. In Vienna, according to the *Lancet*, it has already been found necessary to forbid the sale of antipyrin, except under doctors' prescriptions, as no less than seventeen deaths were attributed to stoppage of the heart's action owing to overdoses. The freedom with which the prescription o this remedy has been assumed by the public has long since been viewed with anxiety by the medical profession, and frequent warnings have already fallen upon deaf ears.

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CONTENTS:

THE WARM WEATHER of this winter has given rise to many theories as to its cause, in some of which the Gulf Stream has figured as an important factor. The Gulf Stream does change its position to a slight amount, but not in the arbitrary manner or to the great extent stated by some of the newspaper writers of late. The usually accepted position of the stream along our coast is that fixed by Professor Bache, based upon temperature observations made by various officers in the navy,—Davis, Lee, Sands, Bache, Craven, Maffitt, and others. The Gulf Stream probably has a vibratory motion, as evidenced by anchorages of the coast survey steamer "Blake" off Cape Hatteras, and off Rebecca Shoal, Florida. Anchored there on the northern edge of the stream, riding to the wind with a gentle current, the latter would suddenly become strong, and swing the vessel until she was stern to the wind, to remain but a short time; and then, the current becoming weaker, the wind would gain the ascendency. This was repeated a number of times Lieut. Pillsbury, U.S.N., who for five years was in command of the "Blake," believes that the daily volume of the stream varies but little, except as due to declination of the moon; that its track through the ocean is absolutely fixed by law; that its vibration is periodic, although the limit of the periodic change may vary to a trifling amount. Along the northern coast, however, it is not always on the surface, but is, from an unknown cause, overrun by other currents. The generally accepted belief, that a wind blowing across the current changes the position of its axis, is, Lieut. Pillsbury is convinced, erroneous. Every temporary wind, however, does transport water (chiefly by means of waves), and with it goes its heat or cold The fact of finding gulf-weed within a few miles of Nantucket lightship does not so much prove that the current is nearer our shores as it does that winds have prevailed in the direction from which it comes.

THE METHOD OF MULTIPLE WORKING HYPOTHESES.[1]

As methods of study constitute the leading theme of our session, I have chosen as a subject in measurable consonance the method of multiple working hypotheses in its application to investigation, instruction, and citizenship.

There are two fundamental classes of study. The one consists in attempting to follow by close imitation the processes of previous thinkers, or to acquire by memorizing the results of their investigations. It is merely secondary, imitative, or acquisitive study. The other class is primary or creative study. In it the effort is to think independently, or at least individually, in the endeavor to discover new truth, or to make new combinations of truth, or at least to develop an individualized aggregation of truth. The endeavor is to think for one's self, whether the thinking lies wholly in the fields of previous thought or not. It is not necessary to this habit of study that the subject-material should be new; but the process of thought and its results must be individual and independent, not the mere following of previous lines of thought ending in predetermined results. The demonstration of a problem in Euclid precisely as laid down is an illustration of the former; the demonstration of the same proposition by a method of one's own or in a manner distinctively individual is an illustration of the latter; both lying entirely within the realm of the known and the old.

Creative study, however, finds its largest application in those subjects in which, while much is known, more remains to be known. Such are the fields which we, as naturalists, cultivate; and we are gathered for the purpose of developing improved methods lying largely in the creative phase of study, though not wholly so.

Intellectual methods have taken three phases in the history of progress thus far. What may be the evolutions of the future it may not be prudent to forecast. Naturally the methods we now urge seem the highest attainable. These three methods may be designated, first, the method of the ruling theory; second, the method of the working hypothesis; and, third, the method of multiple working hypotheses.

In the earlier days of intellectual development the sphere of knowledge was limited, and was more nearly within the compass of a single individual; and those who assumed to be wise men, or aspired to be thought so, felt the need of knowing, or at least seeming to know, all that was known as a justification of their claims. So, also, there grew up an expectancy on the part of the multitude that the wise and the learned would explain whatever new thing presented itself. Thus pride and ambition on the one hand, and expectancy on the other, developed the putative wise man whose knowledge boxed the compass, and whose acumen found an explanation for every new puzzle which presented itself. This disposition has propagated itself, and has come down to our time as an intellectual predilection, though the compassing of the entire horizon of knowledge has long since been an abandoned affectation. As in the earlier days, so still, it is the habit of some to hastily conjure up an explanation for every new phenomenon that presents itself. Interpretation rushes to the forefront as the chief obligation pressing upon the putative wise man. Laudable as the effort at explanation is in itself, it is to be condemned when it runs before a serious inquiry into the phenomenon itself. A dominant disposition to find out what is, should precede and crowd aside the question, commendable at a later stage, "How came this so?" First full facts, then interpretations.

The habit of precipitate explanation leads rapidly on to the development of tentative theories. The explanation offered for a given phenomenon is naturally, under the impulse of self-consistency, offered for like phenomena as they present themselves, and there is soon developed a general theory explanatory of a large class of phenomena similar to the original one. This general theory may not be supported by any further considerations than those which were involved in the first hasty inspec-

[1] Paper read before the Society of Western Naturalists, by President T. C. Chamberlin, Oct. 25, 1889.

tion. For a time it is likely to be held in a tentative way with a measure of candor. With this tentative spirit and measurable candor, the mind satisfies its moral sense, and deceives itself with the thought that it is proceeding cautiously and impartially toward the goal of ultimate truth. It fails to recognize that no amount of provisional holding of a theory, so long as the view is limited and the investigation partial, justifies an ultimate conviction. It is not the slowness with which conclusions are arrived at that should give satisfaction to the moral sense, but the thoroughness, the completeness, the all-sidedness, the impartiality, of the investigation.

It is in this tentative stage that the affections enter with their blinding influence. Love was long since represented as blind, and what is true in the personal realm is measurably true in the intellectual realm. Important as the intellectual affections are as stimuli and as rewards, they are nevertheless dangerous factors, which menace the integrity of the intellectual processes. The moment one has offered an original explanation for a phenomenon which seems satisfactory, that moment affection for his intellectual child springs into existence; and as the explanation grows into a definite theory, his parental affections cluster about his intellectual offspring, and it grows more and more dear to him, so that, while he holds it seemingly tentative, it is still lovingly tentative, and not impartially tentative. So soon as this parental affection takes possession of the mind, there is a rapid passage to the adoption of the theory. There is an unconscious selection and magnifying of phenomena that fall into harmony with the theory and support it, and an unconscious neglect of those that fail of coincidence. The mind lingers with pleasure upon the facts that fall happily into the embrace of the theory, and feels a natural coldness toward those that seem refractory. Instinctively there is a special searching-out of phenomena that support it, for the mind is led by its desires. There springs up, also, an unconscious pressing of the theory to make it fit the facts, and a pressing of the facts to make them fit the theory. When these biasing tendencies set in, the mind rapidly degenerates into the partiality of paternalism. The search for facts, the observation of phenomena and their interpretation, are all dominated by affection for the favored theory until it appears to its author or its advocate to have been overwhelmingly established. The theory then rapidly rises to the ruling position, and investgaton. observation, and interpretation are controlled and directed by it. From an unduly favored child, it readily becomes master, and leads its author whithersoever it will. The subsequent history of that mind in respect to that theme is but the progressive dominance of a ruling idea.

Briefly summed up, the evolution is this: a premature explanation passes into a tentative theory, then into an adopted theory, and then into a ruling theory.

When the last stage has been reached, unless the theory happens, perchance, to be the true one, all hope of the best results is gone. To be sure, truth may be brought forth by an investigator dominated by a false ruling idea. His very errors may indeed stimulate investigation on the part of others. But the condition is an unfortunate one. Dust and chaff are mingled with the grain in what should be a winnowing process.

As previously implied, the method of the ruling theory occupied a chief place during the infancy of investigation. It is an expression of the natural infantile tendencies of the mind, though in this case applied to its higher activities, for in the earlier stages of development the feelings are relatively greater than in later stages.

Unfortunately it did not wholly pass away with the infancy of investigation, but has lingered along in individual instances to the present day, and finds illustration in universally learned men and pseudo-scientists of our time.

The defects of the method are obvious, and its errors great. If I were to name the central psychological fault, I should say that it was the admission of intellectual affection to the place that should be dominated by impartial intellectual rectitude.

So long as intellectual interest dealt chiefly with the intangible, so long it was possible for this habit of thought to survive, and to maintain its dominance, because the phenomena themselves, being largely subjective, were plastic in the hands of the ruling idea; but so soon as investigation turned itself earnestly to an inquiry into natural phenomena, whose manifestations are tangible, whose properties are rigid, whose laws are rigorous, the defects of the method became manifest, and an effort at reformation ensued. The first great endeavor was repressive. The advocates of reform insisted that theorizing should be restrained, and efforts directed to the simple determination of facts. The effort was to make scientific study factitious instead of causal. Because theorizing in narrow lines had led to manifest evils, theorizing was to be condemned. The reformation urged was not the proper control and utilization of theoretical effort, but its suppression. We do not need to go backward more than twenty years to find ourselves in the midst of this attempted reformation. Its weakness lay in its narrowness and its restrictiveness. There is no nobler aspiration of the human intellect than desire to compass the cause of things. The disposition to find explanations and to develop theories is laudable in itself. It is only its ill use that is reprehensible. The vitality of study quickly disappears when the object sought is a mere collocation of dead unmeaning facts.

The inefficiency of this simply repressive reformation becoming apparent, improvement was sought in the method of the working hypothesis. This is affirmed to be *the* scientific method of the day, but to this I take exception. The working hypothesis differs from the ruling theory in that it is used as a means of determining facts, and has for its chief function the suggestion of lines of inquiry; the inquiry being made, not for the sake of the hypothesis, but for the sake of facts. Under the method of the ruling theory, the stimulus was directed to the finding of facts for the support of the theory. Under the working hypothesis, the facts are sought for the purpose of ultimate induction and demonstration, the hypothesis being but a means for the more ready development of facts and of their relations, and the arrangement and preservation of material for the final induction.

It will be observed that the distinction is not a sharp one, and that a working hypothesis may with the utmost ease degenerate into a ruling theory. Affection may as easily cling about an hypothesis as about a theory, and the demonstration of the one may become a ruling passion as much as of the other.

Conscientiously followed, the method of the working hypothesis is a marked improvement upon the method of the ruling theory; but it has its defects,—defects which are perhaps best expressed by the ease with which the hypothesis becomes a controlling idea. To guard against this, the method of multiple working hypotheses is urged. It differs from the former method in the multiple character of its genetic conceptions and of its tentative interpretations. It is directed against the radical defect of the two other methods; namely, the partiality of intellectual parentage. The effort is to bring up into view every rational explanation of new phenomena, and to devleop every tenable hypothesis respecting their cause and history. The investigator thus becomes the parent of a family of hypotheses; and, by his parental relation to all, he is forbidden to fasten his affections unduly upon any one. In the nature of the case, the danger that springs from affection is counteracted, and therein is a radical difference between this method and the two preceding. The investigator at the outset puts himself in cordial sympathy and in parental relations (of adoption, if not of authorship) with every hypothesis that is at all applicable to the case under investigation. Having thus neutralized the partialities of his emotional nature, he proceeds with a certain natural and enforced erectness of mental attitude to the investigation, knowing well that some of his intellectual children will die before maturity, yet feeling that several of them may survive the results of final ivestigation, since it is often the outcome of inquiry that several causes are found to be involved instead of a single one. In following a single hypothesis, the mind is presumably led to a single explanatory conception. But an adequate explanation often involves the co-ordination of

several agencies, which enter into the combined result in varying proportions. The true explanation is therefore necessarily complex. Such complex explanations of phenomena are specially encouraged by the method of multiple hypotheses, and constitute one of its chief merits. We are so prone to attribute a phenomenon to a single cause, that, when we find an agency present, we are liable to rest satisfied therewith, and fail to recognize that it is but one factor, and perchance a minor factor, in the accomplishment of the total result. Take for illustration the mooted question of the origin of the Great Lake basins. We have this, that, and the other hypothesis urged by different students as the cause of these great excavations; and all of these are urged with force and with fact, urged justly to a certain degree. It is practically demonstrable that these basins were river-valleys antecedent to the glacial incursion, and that they owe their origin in part to the pre-existence of those valleys and to the blocking-up of their outlets. And so this view of their origin is urged with a certain truthfulness. So, again, it is demonstrable that they were occupied by great lobes of ice, which excavated them to a marked degree, and therefore the theory of glacial excavation finds support in fact. I think it is furthermore demonstrable that the earth's crust beneath these basins was flexed downward, and that they owe a part of their origin to crust deformation. But to my judgment neither the one nor the other, nor the third, constitutes an adequate explanation of the phenomena. All these must be taken together, and possibly they must be supplemented by other agencies. The problem, therefore, is the determination not only of the participation, but of the measure and the extent, of each of these agencies in the production of the complex result. This is not likely to be accomplished by one whose working hypothesis is pre-glacial erosion, or glacial erosion, or crust deformation, but by one whose staff of working hypotheses embraces all of these and any other agency which can be rationally conceived to have taken part in the phenomena.

A special merit of the method is, that by its very nature it promotes thoroughness. The value of a working hypothesis lies largely in its suggestiveness of lines of inquiry that might otherwise be overlooked. Facts that are trivial in themselves are brought into significance by their bearings upon the hypothesis, and by their causal indications. As an illustration, it is only necessary to cite the phenomenal influence which the Darwinian hypothesis has exerted upon the investigations of the past two decades. But a single working hypothesis may lead investigation along a given line to the neglect of others equally important; and thus, while inquiry is promoted in certain quarters, the investigation lacks in completeness. But if all rational hypotheses relating to a subject are worked co-equally, thoroughness is the presumptive result, in the very nature of the case.

In the use of the multiple method, the re-action of one hypothesis upon another tends to amplify the recognized scope of each, and their mutual conflicts whet the discriminative edge of each. The analytic process, the development and demonstration of criteria, and the sharpening of discrimination, receive powerful impulse from the co-ordinate working of several hypotheses.

Fertility in processes is also the natural outcome of the method. Each hypothesis suggests its own criteria, its own means of proof, its own methods of developing the truth; and if a group of hypotheses encompass the subject on all sides, the total outcome of means and of methods is full and rich.

The use of the method leads to certain peculiar habits of mind which deserve passing notice, since as a factor of education its disciplinary value is one of importance. When faithfully pursued for a period of years, it develops a habit of thought analogous to the method itself, which may be designated a habit of parallel or complex thought. Instead of a simple succession of thoughts in linear order, the procedure is complex, and the mind appears to become possessed of the power of simultaneous vision from different standpoints. Phenomena appear to become capable of being viewed analytically and synthetically at once. It is not altogether unlike the study of a landscape, from which there comes into the mind myriads of lines of intelligence, which are received and co-ordinated simultaneously, producing a complex impression which is recorded and studied directly in its complexity. My description of this process is confessedly inadequate, and the affirmation of it as a fact would doubtless challenge dispute at the hands of psychologists of the old school; but I address myself to naturalists who I think can respond to its verity from their own experience.

The method has, however, its disadvantages. No good thing is without its drawbacks; and this very habit of mind, while an invaluable acquisition for purposes of investigation, introduces difficulties in expression. It is obvious, upon consideration, that this method of thought is impossible of verbal expression. We cannot put into words more than a single line of thought at the same time; and even in that the order of expression must be conformed to the idiosyncrasies of the language, and the rate must be relatively slow. When the habit of complex thought is not highly developed, there is usually a leading line to which others are subordinate, and the difficulty of expression does not rise to serious proportions; but when the method of simultaneous vision along different lines is developed so that the thoughts running in different channels are nearly equivalent, there is an obvious embarrassment in selection and a disinclination to make the attempt. Furthermore, the impossibility of expressing the mental operation in words leads to their disuse in the silent processes of thought, and hence words and thoughts lose that close association which they are accustomed to maintain with those whose silent as well as spoken thoughts run in linear verbal courses. There is therefore a certain predisposition on the part of the practitioner of this method to taciturnity.

We encounter an analogous difficulty in the use of the method with young students. It is far easier, and I think in general more interesting, for them to argue a theory or accept a simple interpretation than to recognize and evaluate the several factors which the true elucidation may require. To illustrate: it is more to their taste to be taught that the Great Lake basins were scooped out by glaciers than to be urged to conceive of three or more great agencies working successively or simultaneously, and to estimate how much was accomplished by each of these agencies. The complex and the quantitative do not fascinate the young student as they do the veteran investigator.

It has not been our custom to think of the method of working hypotheses as applicable to instruction or to the practical affairs of life. We have usually regarded it as but a method of science. But I believe its application to practical affairs has a value co-ordinate with the importance of the affairs themselves. I refer especially to those inquiries and inspections that precede the coming-out of an enterprise rather than to its actual execution. The methods that are superior in scientific investigation should likewise be superior in those investigations that are the necessary antecedents to an intelligent conduct of affairs. But I can dwell only briefly on this phase of the subject.

In education, as in investigation, it has been much the practice to work a theory. The search for instructional methods has often proceeded on the presumption that there is a definite patent process through which all students might be put and come out with results of maximum excellence; and hence pedagogical inquiry in the past has very largely concerned itself with the inquiry, "What is the best method?" rather than with the inqiry, "What are the special values of different methods, and what are their several advantageous applicabilities in the varied work of instruction?" The past doctrine has been largely the doctrine of pedagogical uniformitarianism. But the faculties and functions of the mind are almost, if not quite, as varied as the properties and functions of matter; and it is perhaps not less absurd to assume that any specific method of instructional procedure is more effective than all others, under any and all circumstances, than to asume that one principle of interpretation is equally applicable to all the phenomena

of nature. As there is an endless variety of mental processes and combinations and an indefinite number of orders of procedure, the advantage of different methods under different conditions is almost axiomatic. This being granted, there is presented to the teacher the problem of selection and of adaptation to meet the needs of any specific issue that may present itself. It is important, therefore, that the teacher shall have in mind a full array of possible conditions and states of mind which may be presented, in order that, when any one of these shall become an actual case, he may recognize it, and be ready for the emergency.

Just as the investigator armed with many working hypotheses is more likely to see the true nature and significance of phenomena when they present themselves, so the instructor equipped with a full panoply of hypotheses ready for application more readily recognizes the actuality of the situation, more accurately measures its significance, and more appropriately applies the methods which the case calls for.

The application of the method of multiple hypotheses to the varied affairs of life is almost as protean as the phases of that life itself, but certain general aspects may be taken as typical of the whole. What I have just said respecting the application of the method to instruction may apply, with a simple change of terms, to almost any other endeavor which we are called upon to undertake. We enter upon an enterprise in most cases without full knowledge of all the factors that will enter into it, or all of the possible phases which it may develop. It is therefore of the utmost importance to be prepared to rightly comprehend the nature, bearings, and influence of such unforeseen elements when they shall definitely present themselves as actualities. If our vision is narrowed by a preconceived theory as to what will happen, we are almost certain to misinterpret the facts and to misjudge the issue. If, on the other hand, we have in mind hypothetical forecasts of the various contingencies that may arise, we shall be the more likely to recognize the true facts when they do present themselves. Instead of being biased by the anticipation of a given phase, the mind is rendered open and alert by the anticipation of any one of many phases, and is free not only, but is predisposed, to recognize correctly the one which does appear. The method has a further good effect. The mind, having anticipated the possible phases which may arise, has prepared itself for action under any one that may come up, and it is therefore ready-armed, and is predisposed to act in the line appropriate to the event. It has not set itself rigidly in a fixed purpose, which it is predisposed to follow without regard to contingencies. It has not nailed down the helm and predetermined to run a specific course, whether rocks lie in the path or not; but, with the helm in hand, it is ready to veer the ship according as danger or advantage discovers itself.

It is true, there are often advantages in pursuing a fixed predetermined course without regard to obstacles or adverse conditions. Simple dogged resolution is sometimes the salvation of an enterprise; but, while glorious successes have been thus snatched from the very brink of disaster, overwhelming calamity has in other cases followed upon this course, when a reasonable regard for the unanticipated elements would have led to success. So there is to be set over against the great achievements that follow on dogged adherence great disasters which are equally its result.

The tendency of the mind, accustomed to work through multiple hypotheses, is to sway to one line of policy or another, according as the balance of evidence shall incline. This is the soul and essence of the method. It is in general the true method. Nevertheless there is a danger that this yielding to evidence may degenerate into unwarranted vacillation. It is not always possible for the mind to balance evidence with exact equipoise, and to determine, in the midst of the execution of an enterprise, what is the measure of probability on the one side or the other; and as difficulties present themselves, there is a danger of being biased by them and of swerving from the course that was really the true one. Certain limitations are therefore to be placed upon the application of the method, for it must be remembered that a poorer line of policy consistently adhered to may bring better results than a vacillation between better policies.

There is another and closely allied danger in the application of the method. In its highest development it presumes a mind supremely sensitive to every grain of evidence. Like a pair of delicately poised scales, every added particle on the one side or the other produces its effect in oscillation. But such a pair of scales may be altogether too sensitive to be of practical value in the rough affairs of life. The balances of the exact chemist are too delicate for the weighing-out of coarse commodities. Despatch may be more important than accuracy. So it is possible for the mind to be too much concerned with the nice balancings of evidence, and to oscillate too much and too long in the endeavor to reach exact results. It may be better, in the gross affairs of life, to be less precise and more prompt. Quick decisions, though they may contain a grain of error, are oftentimes better than precise decisions at the expense of time.

The method has a special beneficent application to our social and civic relations. Into these relations there enter, as great factors, our judgment of others, our discernment of the nature of their acts, and our interpretation of their motives and purposes. The method of multiple hypotheses, in its application here, stands in decided contrast to the method of the ruling theory or of the simple working hypothesis. The primitive habit is to interpret the acts of others on the basis of a theory. Childhood's unconscious theory is that the good are good, and the bad are bad. From the good the child expects nothing but good; from the bad, nothing but bad. To expect a good act from the bad, or a bad act from the good, is radically at variance with childhood's mental methods. Unfortunately in our social and civic affairs too many of our fellow-citizens have never outgrown the ruling theory of their childhood.

Many have advanced a step farther, and employ a method analogous to that of the working hypothesis. A certain presumption is made to attach to the acts of their fellow-beings, and that which they see is seen in the light of that presumption, and that which they construe is construed in the light of that presumption.[14] They do not go to the lengths of childhood's method by assuming positively that the good are wholly good, and the bad wholly bad; but there is a strong presumption in their minds that he concerning whom they have an ill opinion will act from corresponding motives. It requires positive evidence to overthrow the influence of the working hypothesis.

The method of multiple hypotheses assumes broadly that the acts of a fellow-being may be diverse in their nature, their motives, their purposes, and hence in their whole moral character; that they may be good though the dominant character be bad; that they may be bad though the dominant character be good; that they may be partly good and partly bad, as is the fact in the greater number of the complex activities of a human being. Under the method of multiple hypotheses, it is the first effort of the mind to see truly what the act is, unbeclouded by the presumption that this or that has been done because it accords with our ruling theory or our working hypothesis. Assuming that acts of similar general aspect may readily take any one of several different phases, the mind is freer to see accurately what has actually been done. So, again, in our interpretations of motives and purposes, the method assumes that these may have been any one of many, and the first duty is to ascertain which of possible motives and purposes actually prompted this individual action. Going with this effort there is a predisposition to balance all evidence fairly, and to accept that interpretation to which the weight of evidence inclines, not that which simply fits our working hypothesis or our dominant theory. The outcome, therefore, is better and truer observation and juster and more righteous interpretation.

There is a third result of great importance. The imperfections of our knowledge are more likely to be detected, for there will be less confidence in its completeness in proportion as there is a broad comprehension of the possibilities of varied action, under similar circumstances and with similar appearances.

So, also, the imperfections of evidence as to the motives and purposes inspiring the action will become more discernible in proportion to the fulness of our conception of what the evidence should be to distinguish between action from the one or the other of possible motives. The necessary result will be a less disposition to reach conclusions upon imperfect grounds. So, also, there will be a less inclination to misapply evidence; for, several constructions being definitely in mind, the indices of the one motive are less liable to be mistaken for the indices of another.

The total outcome is greater care in ascertaining the facts, and greater discrimination and caution in drawing conclusions. I am confident, therefore, that the general application of this method to the affairs of social and civic life would go far to remove those misunderstandings, misjudgments, and misrepresentations which constitute so pervasive an evil in our social and our political atmospheres, the source of immeasurable suffering to the best and most sensitive souls. The misobservations, the misstatements, the misinterpretations, of life may cause less gross suffering than some other evils; but they, being more universal and more subtle, pain. The remedy lies, indeed, partly in charity, but more largely in correct intellectual habits, in a predominant, ever-present disposition to see things as they are, and to judge them in the full light of an unbiased weighing of evidence applied to all possible constructions, accompanied by a withholding of judgment when the evidence is insufficient to justify conclusions.

I believe that one of the greatest moral reforms that lies immediately before us consists in the general introduction into social and civic life of that habit of mental procedure which is known in investigation as the method of multiple working hypotheses.

AMONG THE PUBLISHERS.

SPEAKING of Professor Carl Lumholtz's "Among Cannibals," the *Athenæum* says that "the volume is not only agreeable reading throughout, but is full of curious information."

— In the *Jenness Miller Magazine* for February is a physical culture article by Miss Jenness. "The History of St. Valentine's Day," by Laura Giddings, suggests a new form of entertainment for modern society.

— In the *Electrical World* of Jan. 11 was an illustrated article descriptive of the new and handsomely equipped offices of that enterprising paper, which occupy the better part of a floor in the recently finished Times Building on Park Row, this city,— one of the finest office buildings in the world.

— The brother of President Harrison's private secretary, Mr. A. J. Halford, has written for the March number of the Philadelphia *Ladies' Home Journal* an article on "Mrs. Harrison's Daily Life in the White House," prepared with the consent and assistance of Mrs. Harrison.

— It is thought that the death of Mr. Frank Marshall will cause no delay in the publication of the eighth and final volume of the "Henry Irving Shakespeare." Mr. Marshall's arduous labors on this work were the indirect cause of his illness. The eighth volume, by the way, will contain "Hamlet."

— One of the gravest and most important problems that confront the American people relates to the hundreds of thousands of immigrants who pour into this country every year. In a timely book, soon to be published by the Scribners, Richmond M. Smith, professor of political economy in Columbia College, discusses the historical, statistical, economic, ethnic, and social aspects of this interesting question.

—''Laugh and Learn'' is the title of a book of nursery lessons and nursery games, by Jennett Humphreys, with many illustrations. The union of simple instruction and amusement is happily carried out. The book will be published by Scribner & Welford.

— Under the title of ''The Religious Aspect of Evolution,'' Dr. James McCosh's series of lectures delivered in 1887 at the Theological Seminary of the Diocese of Ohio and Kenyon College will be published by the Scribners. The chapter on ''Final Cause'' is entirely new.

— Professor Frederick L. Ritter of Vassar has revised and enlarged his popular history of ''Music in America,'' and the new edition will be brought out soon by the Scribners. The author has continued to date the history of the leading musical organizations and of the opera in different cities, adding about a hundred pages to the book.

— Two new volumes of ''The Uncollected Writings of Thomas De Quincey,'' with a preface and annotations by James Hogg, are announced by Scribner & Welford. The volumes contain many entertaining essays; ''Shakespeare's Text,'' ''How to Write English,'' ''The Casuistry of Duelling,'' and ''The Love-Charm,'' being a few of the titles.

—As a memorial of a distinguished administrator, and to further the cause of imperial federation, Mr. Stanley Lane-Poole has edited the papers of Sir George Bowen, and they will be published immediately in London and New York by Longmans, Green, & Co. In one of Sir George's earlier letters there is a pleasant glimpse of Washington society during Grant's administration.

— The ''Truth Seeker Annual and Freethinkers' Almanac'' for 1890 (28 Lafayette Place, New York) contains, among numerous other interesting articles, an account of the inauguration of the Bruno statue in Rome, by T. B. Wakeman; some investigations into the phenomena of Spiritualism, by E. M. Macdonald; and a history of the progress of free thought in the United States during 1889. The book is handsomely illustrated.

— Our readers will learn with interest that the Scribners will issue this month the third and fourth volumes of Henry Adams's ''History of the United States.'' The first two volumes treated of Jefferson's first administration, — 1801 to 1805; the forthcoming two volumes relate to the great Democratic leader's second term of office, — 1805 to 1809. The new volumes are said to contain considerable new material bearing upon the Burr conspiracy and other events of the period.

— The January number of the *American Naturalist* is at hand. It contains, beside another instalment of E. L. Sturtevant's treatise on the ''History of Garden Vegetables,'' an illustrated article by J. W. Fewkes, on the habit of certain sea-urchins of boring holes in the rocks to which they are attached, and a suggestive article by R. E. C. Stearns on ''The Effects of Musical Sounds upon Animals.'' We note the fact that this number appears almost on time; and as the present publishers, the Messrs. Ferris Brothers, of Sixth and Arch Streets, Philadelphia, have been sending out the numbers at the rate of two a month since they assumed control, it is only fair to infer that the magazine will henceforth appear on its nominal date. There are still three numbers to be furnished of the year 1889; but these will be printed and sent out as rapidly as possible, and in the mean time the current issues for 1890 will proceed with regularity.

— The Publication Agency of the Johns Hopkins University, Baltimore, has just issued ''The Beginnings of American Nationality,'' by President Small of Colby University, commencing the series for 1890 of ''Studies in Historical and Political Science;'' also ''The Needs of Self-Supporting Women,'' by Miss Clare de Graffenried of the Department of Labor, Washington, D.C., being No. 1 (for 1890) of the ''Notes Supplementary to the Studies in Historical and Political Science.'' It is proposed, also, to collect and publish, in a limited edition, the principal literary essays and studies of Professor Gildersleeve. They will make a volume of between three hundred and four hundred pages. The following is a list of the titles of the essays: 1. ''Limits of Culture;'' 2. ''Classics and Colleges;'' 3. ''University Work in America;'' 4. ''Grammar and Aesthetics;'' 5. ''Legend of Venus; 6. ''Xanthippe and Socrates;'' 7. ''Apollonius of Tyana;'' 8. ''Lucian;'' 9. ''The Emperor Julian;'' 10. ''Platen's Poems:'' 11. ''Maximilian, Emperor of Mexico;'' 12. ''Occasional Addresses.''

— Of the contents of *The Chautauquan* for February we note ''The Politics which Made and Unmade Rome,'' by President C. K. Adams, LL.D.; ''The Politics of Mediæval Italy,'' by Professor Philip Van Ness Myers, A.M.; ''The Archæological Club at Rome,'' by James A. Harrison, LL.D., Lit.D.; ''Life in Mediæval Italy,'' by the Rev. Alfred J. Church, M.A.; ''Economic Internationalism,'' by Richard T. Ely, Ph.D.; ''Moral Teachings of Science,'' by Arabella B. Buckley; ''The Works of the Waves,'' by Professor N. S. Shaler; ''Traits of Human Nature,'' by J. M. Buckley, LL.D; ''Modern English Politics and Society,'' by J. Ranken Towse; ''How Sickness was prevented at Johnstown,'' by Dr. George Groff; ''Trusts and How to Deal with Them,'' by George Gunton; and ''Divorce in the United States,'' by Oliver Cornell.

LETTERS TO THE EDITOR.

**** *Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.*

The editor will be glad to publish any queries consonant with the character of the journal.

Physical Fields.

IT seems probable that the articles which have appeared in this journal on this subject — one by A. E. Dolbear on Dec. 27, and the other by N. W. Perry on Jan. 24 — are the most important that have been recently written as bearing especially upon present theories in meteorology. It is of the utmost consequence that in this complex science we lay a sure foundation of fact, and never be tempted to speculations unless supported in the main by observations. It is not my purpose, even if I were able, to discuss the questions at issue in these papers, but I wish to present what seems to me may prove a most important field for research, hoping that others may take up the matter and shed light upon the problem.

The ''thermal field'' is probably the easiest to comprehend. We may conceive a white-hot cannon-ball in space. It radiates its heat equally in all directions, and is rapidly cooled. We may measure the distance to which these radiations extend. If these radiations be intercepted by any body, it in turn will be heated, and send back its radiations to the ball; and these exchanges will continue till a thermal equilibrium be established. All orthodox theories in meteorology regard the sun as a hot ball in space; that its rays impinge upon the earth, passing through the atmosphere without heating it; that this heated earth sets up convection currents in the atmosphere; and, finally, that all our winds and storms are primarily induced by these convection currents. I believe the time is not far distant when this theory will appear puerile in the extreme, and it will be acknowledged that the actions produced in any locality through the direct heat agency of the sun must be greatest just at the time when there are *no* storms, and all of them combined will not account for a hundredth part of the energy developed.

The ''electric field'' is the one I wish to specially notice. Mr. Perry, speaking of electrification, says, ''It is a condition which is dual in its character. The negative exists because of the existence of the positive, not because of propagation from one to another. . . . We must regard electricity as motion; electrification, one kind of stress which is capable of producing electrical vibrations; magnetism may be another.'' Granting the existence of such a dual condition, without at present going into the question of how it can be energized or brought about, I wish to inquire what may be told or inferred as to the action of individual electrified particles in either the positive or negative portion of such a dual condition, let us say, in the atmosphere.

Take, for example, the electric arc. As I understand it, particles of carbon are continuously carried from what is called

the positive pole to the negative, and the latter is built up at the expense of the former. I do not know that the velocity of these particles has even been estimated, but it must be exceedingly small as compared with that of electricty (186,000 miles per second). Suppose we have a positive and a negative electric field, or dual condition, in a dusty atmosphere: may we not say that the dust in the positive field, if sufficiently electrified, will have a tendency to pass toward the negative field? Or, if we consider that moisture particles take the place of dust, why may not these, positively electrified, have a tendency toward the negative field? We have an illustration on a large scale in the case of thunder-clouds which have been repeatedly seen to approach each other. Mr. Dolbear writes me that he has himself noted a most remarkable and sudden clearing of clouds after a thunder-storm. I have myself observed a line of blackness gradually advance in a clear sky, the line stretching from the south-east to the north-west. The demarcation between the clear sky and the black cloud was almost geometrical in its sharpness. No rain was felt till the edge of the cloud reached the zenith; and then rain fell in torrents, though there was blue sky almost directly overhead.

But there is a still more important consideration. The difficulty of changing the moisture contents of the air is universally recognized. The number of grains per cubic foot will remain absolutely constant for days at a time, no matter what may be the heat conditions of the earth, its winds, clouds, or any other changes in the meteorological elements. A sixteen-hours' steady rain has not been sufficient to saturate the air. Nothwithstanding these facts, we now know that accompanying a storm, and independent of the sun's heat, there are most extraordinary fluctuations in the moisture contents of the air. Frequently, over an area of 160,000 square miles, this moisture may be doubled, and immediately following the storm it may be diminished three-quarters of this; and this, too, absolutely independent of the wind, pressure, or temperature. I will give but one illustration. On Dec. 22, 1889, at 3.11 P.M., I observed 4.09 grains of moisture per cubic foot in the air, which was calm at the time. At 5.2 P.M., or 111 minutes later, there were only 1.04 grains per cubic foot. This was certainly the greatest diminution I ever observed, but several times I have observed it almost as great. Without going into the questions, which this discussion must raise, it seems to me that such extraordinary changes can be abundantly accounted for on the principles enunciated in this journal, and cannot be accounted for in any other way. What we need most of all are experimental determinations showing the possibility of such transfer in electric fields. Have we any help from the difficulty of running a Holtz machine in a damp room, from the gathering of dust and lint on electrified glass rods? Is it possible to electrify a mass of air so as to test any of these questions? Thus far I have hoped only to interest others more familiar with the subject than myself. I do not expect that I have added any thing to our knowledge; but as Professor Holden has said recently, regarding photographic magnitudes of stars, "any discussion of the question at this stage can but be advantageous," so it seems to me in this field of research we may well consider that any consideration of the questions involved must tend to bring out the best thoughts of many minds; and "in the multitude of counsellors there is wisdom."

H. A. HAZEN.

Northfield, Minn., Jan. 28.

IN my communication on physical fields published in *Science* of Dec. 27, what I was most desirous of pointing out was the character of the physical re-action of a field of a given sort upon a body in it. The explanation of the various steps was unessential, entirely so; and if my explanations were not the true explanations, the conclusions reached in the main thesis would not be vitiated.

Mr. N. W. Perry takes some exceptions to my terminology, which are proper enough if I have not used appropriate terms. I most heartily agree that in all departments of science the terms used should be explicit, definite, and not misleading; but it is unfortunate indeed that all through physics, to say nothing of other sciences, there is no general agreement as to the proper use of terms. Take, for instance, the term "heat." Some say "heat is vibratory atomic or molecular motion," others just as competent say "heat is a form of energy." Now, both cannot be right, unless a mode of motion is a form of energy. Again, note the long controversy lately had in England over the proper use of the words "mass" and "weight."

The significance of it is this: that, until there is a well-settled use of a word in a technical sense, one cannot be altogether blamed if he uses the word in a sense different from some other one. Now, Mr. Perry is certain that I do not use the word "stress" properly; that it "is not proper to say that a stress travels;" that Maxwell and others do not believe that electrification involves motion in any way; that potential conditions or energy are static, and that I have made a fundamental mistake in not discriminating between static and kinetic energy.

To all this I have to reply,

1st, Suppose an electrometer to be, say, one metre from a glass rod which I electrify with a piece of silk. If the electrometer gives any indication of electrification, the condition that incites it has travelled with a finite velocity. Whether it be called a stress, a strain, or any thing else, is immaterial; whether it is a condition of the ether or action at a distance in the sense the older philosophers thought, does not matter so much if it takes time to go from the glass rod to the electrometer. One may call it potential or kinetic energy if he chooses: a static condition will presently be reached, but not instantly. And the same is true of the effect produced by magnetizing a piece of iron.

Mr. Perry seems to say, that, if there was but one body in the universe, it could not have an electric field, even if it could be electrified. If that be his meaning, I must say that his conception of electrical re-actions is totally different from mine. As Tait has it, "every action between two bodies is a stress." The body and the ether about it are two bodies; and, if they can act at all upon each other, there will then be a field. Perhaps, however, Mr. Perry calls the ether matter, which has not been my habit, and against which I was not on my guard when I wrote the statement to which he objects. Until we have some evidence that ether is subject to the law of gravitation, it seems to me to be improper to speak of it as matter. If "every particle of matter attracts every other particle of matter," and if there is no evidence that ether is so attracted, it is not conducive to good terminology to call it matter.

2d, This term "stress" has not been long in use at all, and the adoption of it into electrical science I suppose to be due chiefly to Maxwell. I have therefore looked to see how he employed it, and I find the following in his treatise on "Electricity and Magnetism," Art. 866:—

"Now, we are unable to conceive of propagation in time, except either as the flight of a material substance through space, or as *the propagation of a condition of motion or stress* in a medium already existing in space." The Italics are mine, as I interpret them to mean precisely what I meant. Evidently Maxwell did conceive that stress could travel.

Again, in Art. 863 he says, "The emitted potential *flows* to the body;" and once more, "The potential as received by the attracted body is identical with, or equal to, the potential that arrives at it;" and once more, "The velocity of transmission of the potential is not like that of light, constant relative to the ether or to space, but rather like that of a projectile, constant relative to the velocity of the emitting particle at the instant of emission."

These quotations seem to me to justify me in the use of the word "stress" as a condition capable of translation from one point to another. It is not unlikely, though, that within the past few years, and since Maxwell's death, the term has become more precise; and that, if true, would justify calling attention to a departure from such use.

A. E. DOLBEAR.

College Hill, Mass, Feb. 2.

Pressure-Waves.

CAZENOVIA LAKE, or more properly "Owahgena," is about four miles long and half a mile wide, situated twelve hundred feet above sea-level. The outlet issues from one corner, and is a deep curved channel. Two hundred feet from the lake an artificial pond connects with the outlet. A dam at the neck of this pond rises to within four inches of the surface of the water. No ordinary waves reach this point, but it affords an unusually good opportunity for observing the long waves that are evidently caused by varying atmospheric pressure, apart rom the frictional force that produces the common waves. When the water is perfectly smooth on each side of this dam, which is protected from wind-currents, it flows with such speed over the dam as to show a decided ripple. The flow is alternately in and out of the pond, which has no other opening, and it changes direction about every five minutes. The change of level is from three-quarters of an inch to an inch.

If the speed of this long low wave is the same as the small swells on the lake, ten minutes from crest to crest would indicate that the crests are about one mile apart, — a very long wave with an inch elevation. The phenomenon is regular for hours, and seems to depend very little upon the force of the wind, showing no connection with the wind's direction. If local storms prevail, the energy of this motion is increased very much in excess of the force of the wind felt on the lake.

The variation of atmospheric weight needed to produce this effect would probably be a little less than an ounce to the square foot, or an inch and a half on a water barometer. It suggests a low-tide rise and fall, with eight to ten minute intervals. It would be interesting to know if more skilled observers have given attention to water indications of air-pressure of this kind.

To-day there is ice on the lake two or three inches thick; the wind south, in strong gusts. At the south end, where the wind is offshore, and at a very sheltered point, I notice, at about eight-minute intervals, a rise of the water made evident by the cracking of the crust that connects the ice with the shore, showing that the long wave acts under the ice in the same way as when the lake is open. L. W. LEDYARD.

Cazenovia, N.Y., Feb. 2.

Influenza.

I LIVE on the Sioux Reservation, thirty-two miles from Fort Yates, the nearest white settlement. We have had a clear cold winter, west winds prevailing, few colds, and but little sickness except whooping-cough among children.

Over on the other side of the river, north of this about thirty or forty miles, is a Russian settlement. I have heard continually of late of their having influenza over there. I had no faith in the disease being an epidemic or contagious. A short time ago a few of our Indians went over there trading. We had no signs of the disease here. They returned, and in less than a week one of the families who went were all down with what I thought hard colds. I was called in to treat the cases. In three days, three more strong men were down; and now the whole Indian village is suffering with it, and I am just coming down with it myself. The patients have aching heads, and pain in the side and lungs, the whole body aching as if with ague. They are feverish, troubled with coughing and hoarseness, are restless, and have no appetites, but great thirst. Is it influenza? If so, influenza must be contagious. We have such cold weather, surely disease-germs would not survive; and our winds, being mostly west winds, could not bring disease-germs from the east. This may be of no use to science; but I am so isolated here, — being a missionary among the Indians, and the only white person here, — I thought it might have weight in some direction. M. C. COLLINS.

Fort Yates, N.Dak., Jan. 24.

Lightning Discharge.

IN response to invitation in the last number of *Science*, I send description of lightning discharge.

In the summer of 1883, when our present public high-school building was nearly completed, but before the lightning-rods were in place, a carved brownstone "finial" in the form of a double cross, weighing about a hundred pounds, which stood on one end of the roof of the building, was struck by lightning. No trace of the lightning was found on any part of the buliding below this "finial" stone, which was apparently blown to pieces as effectually as if an ounce of gunpowder had been enclosed in its centre, and fired by electricity. It was just before a thunder-shower, but not a drop of rain had fallen. The writer was within twenty rods of the building at the time, and helped pick up the fragments (all of which have been preserved), which were scattered over a space of thirty feet radius.

Was the cloud negative, and did the positive discharge go upward? JOSEPH HALL.

Hartford, Conn., Jan. 29.

CALENDAR OF SOCIETIES.

Philosophical Society, Washington.

Feb. 1. — C. Hart Merriam, General Results of a Biological Survey of the San Francisco Mountain Region in Arizona; B. E. Ferrow, Forest Influences on Water Supplies.

Boston Society of Natural History.

Feb. 5. — F. W. Putnam, Early Man in America; S. H. Scudder, Remarks on a Small Collection of Beetles from the Interglacial Clays of Scarboro', Ontario.

Exchanges

[Free of charge to all, if of satisfactory character. Address N. D. C. Hodges, 47 Lafayette Place, New York.]

Wanted—Books and journals, American or foreign, relating to Photography—exchange or purchase. C. W. Canfield, 1,321 Broadway, New York.

Wanted.—Marine univalves of the west coast, from U. S. line southward, and from Pacific Islands, offered; exchange from a general collection. — F. C. Browne, Framingham, Mass., Box 50.

D. E. Willard, Curator of the Museum, Albion Academy, Albion, Wis., will answer all his correspondence as soon as possible. Sickness and death in the family, with many other matters, have prevented his answering as promptly as he should have done.

I will give 100 good arrow heads for a fine pair of wild cattle horns at least two feet long. If you have shorter or other horns write me, and also how many arrow heads you want for them. I will also exchange shells, minerals and arrows. W. F. Lerch, 308 East 4th St., Davenport, Iowa.

I wish to purchase Vol. 7 of the *American Chemical Journal*, either bound or unbound. State price. Address, Wm. L. Dudley, Vanderbilt University, Nashville, Tenn.

A few duplicates of *Murex radix*, *M. ramosus*, *M. brandaris*, *Cassis rufa*, *Harpa ventricosa*, *Oliva triatula*, *O. reticularis*, *Chlorostoma funebrale*, *Cypræa caput serpentis*, *C. lynx*, *Lottia gigantea*, *Acmola patina*, *Chama spinosa*, and some thirty other species, for exchange for shells not in our collection. List on application. — Curator Museum, Polytechnic Society, Louisville, Ky.

Photographs and Stereoscopic views of Aborigines of any country, and fine landscapes etc., wanted in exchange for minerals and fossils. — L. L. Lewis, Copenhagen, New York.

Droysen's *Algemeiner Historicher Hand-atlas* (Leipzig, 1886,) for scientific books – those published in the *International Scientific Series* preferred.—James H. Stoller, Schenectady, N.Y.

Astronomical works and reports wanted in exchange or to buy. Reports of observations on the planet Neptune and its satellite specially desired — Edmund J. Sheridan, B.A., 295 Adelphi St., Brooklyn, N.Y.

I would like to correspond with any person having Tryon's "Structural and Systematic Conchology" to dispose of. I wish also to obtain State or U.S. Reports on Geology, Conchology, and Archæology. I will exchange classified specimens or pay cash. Also wanted a copy of MacFarlane's "Geologists' Traveling Hand-Book and Geological Railway Guide." — D. E. Willard, Curator of Museum, Albion Academy, Albion, Wis.

Morris's "British Butterflies," Morris's "Nests and Eggs of British Birds," Bree's "Birds of Europe" (all colored plates), and other natural history, in exchange for Shakesperiana; either books, pamphlets, engravings, or cuttings. — J. D. Barnett, Box 735, Stratford, Canada.

I have *Anodonta opalina* (Weatherby), and many other species of shells from the noted Koshkonong Lake and vicinity, also from Western New York, and fossils from the Marcellus shale of New York, which I would be glad to exchange for specimens of scientific value of any kind. I would also like to correspond with persons interested in the collection, sale, or exchange of Indian relics.—D. E. Willard, Albion Academy, Albion, Wis.

Will exchange "Princeton Review" for 1883, Hugh Miller's works on geology and other scientific works, for back numbers of "The Auk," "American Naturalist," or other scientific periodicals or books. Write.— J. M. Keck, Chardon, Ohio.

Shells and curiosities for marine shells, curiosities or minerals address W. F. Lerch, No. 308 East Fourth St., Davenport, Iowa.

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Wants.

Any person seeking a position for which he is qualified by his scientific attainments, or any person seeking some one to fill a position of this character, be it that of a teacher of science, chemist, draughtsman, or what not, may have the 'Want' inserted under this head FREE OF COST, *if he satisfies the publisher of the suitable character of his application. Any person seeking information on any scientific question, the address of any scientific man, or who can in any way use this column for a purpose consonant with the nature of the paper, is cordially invited to do so.*

A YOUNG MAN desires, about the 1st of July, a position as laboratory assistant, or as instructor in chemistry, physics, and lesser mathematics. References as to ability and character. 44 P.M.A. Address R. L. Porter, Penn. Mil. Acad., Chester, Pa.

PRACTICAL CHEMIST, with 10 years' experience in superintending manufacture of oil of vitrol, fertilizers, acetic acid, wood alcohol, etc., is open to an engagement. Bestre ferences. P. O. Box 43, Edgewater, Bergen Co., N. J.

AN M. S. GRADUATE of the University of Illinois is open for an engagement as teacher of the Natural Sciences, Biology a specialty, in an Academy, Institute, or High School. Three years' experience. Is a practical assayer and chemist. Good references. Address G. C., care SCIENCE.

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I WILL ASSIST in photographic or optical laboratory in return for experience and convenience of perfecting original appliances. Address E. C. Owen, care of Gibson & Simpson, 9½ Adelaide Street East, Toronto, Canada.

AN ANALYTICAL CHEMIST is open to an engagement in mining, metallurgy, calico printing, and bleaching, or as research chemist in alkali manufacture. Address "Alkali," care of SCIENCE.